First results of the search for $Z \to b\bar{b}$ and plans for the future

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Introduction: Why $Z \to b\bar{b}$?

The $Z \to b\bar{b}$ studies offer the possibility of determine the resolution reachable in the di-jet mass spectra of b-jets.

The study of this known channel then offers the possibility of:

- test and tune b-specific **jet corrections**;
- understand the **status** of the **SecVtX** tagging algorithm.

This information can be used in different scenarios involving events containg b-jets, such as:

- The **associated Higgs production** in purely **hadronic final state**;
- The $t\bar{t}$ **production** in **6 jets** final state.

Triggers Simulations

In Run I, to see $Z \to b\bar{b}$ decays, we triggered on muons.
In Run II, with SVT we trigger on Impact Parameter of tracks.

In that way, the two most promising and unbiased trigger paths to search the $Z \to b\bar{b}$ signal are the:

- **Z_BB** trigger: $\sigma_{\mathbf{trg}} \sim$ **12 nb**;
- **High_Pt_B_Jets** trigger: $\sigma_{\mathbf{trg}} \sim$ **120 nb**;

In order to estimate the number of signal events we expect in a given sample of collected data, we have to determine the efficiency of these triggers on the signal we are interested in.

This is done performing a **trigger simulation** based on the information contained in the **Trigger Tables** and in the **Level 3 tcls**.

In the following slides I'll review the triggers requirements and present the efficiency on $Z \to b\bar{b}$ signal for each trigger level.

Trigger Simulation : Z_BB

Level 1

- 2 XFT tracks with $P_T > 4\ GeV$ and $150° < \Delta(\phi)_{tt} < 180°$.

Level 2

- 2 SVT tracks with $P_T > 4\ GeV$, $\chi^2 < 25$ and $120\ \mu m < |d| < 1\ mm$.

Level 3

- 2 jet ($E_T > 10\ GeV$) (0.7 cone)
- 1 SVT+COT track with $P_T > 6\ GeV$, $|\eta| < 1.2$ and $120\ \mu m < |d| < 1\ mm$;
- 1 SVT+COT track with $P_T > 4\ GeV$, $|\eta| < 1.2$ and $120\ \mu m < |d| < 1\ mm$;
- $\Delta(\phi)_{tt} > 150°$

Trigger Level	ϵ_{Signal} (%)
Level 1	22.30 ± 0.13
Level 2	4.40 ± 0.06
Level 3	0.85 ± 0.03

Trigger Simulation : High_Pt_B_Jet

Level 1

- 2 XFT tracks with $P_T > 2\ GeV$ and $0^\circ \leq \Delta(\phi)_{tt} \leq 180^\circ$
- 2 Central Towers $E_T > 5\ GeV$

Level 2

- 2 SVT tracks with $P_T > 2\ GeV$, $\chi^2 < 25$ and $100\ \mu m < |d| < 1\ mm$

Level 3

- 2 jet ($E_T > 20\ GeV$) (0.4 cone)
- 2 SVT+COT tracks with $P_T > 2\ GeV$ $|\eta| < 1.2$ and $100\ \mu m < |d| < 1\ mm$

Trigger Level	ϵ_{Signal} (%)
Level 1	37.98 ± 0.34
Level 2	14.22 ± 0.24
Level 3	6.24 ± 0.17

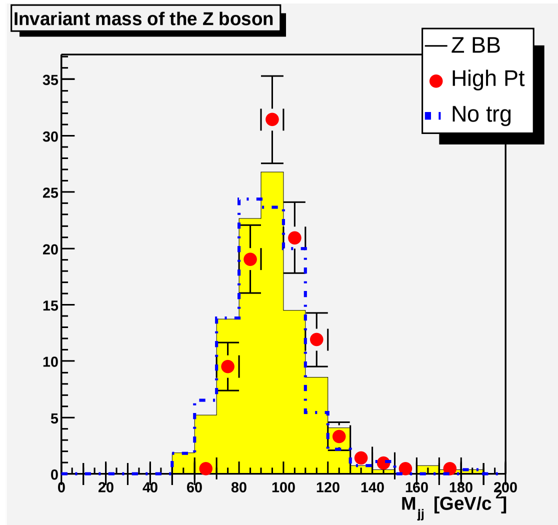
Trigger biases on M_Z

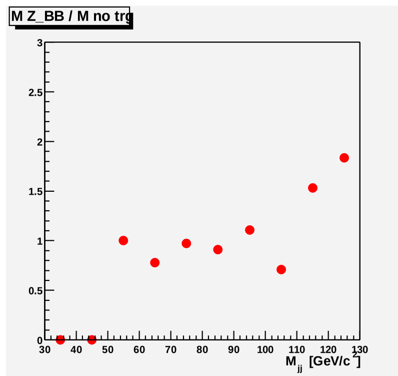
In order to estimate the bias introduced by the triggers on the invariant mass of the b-jets outcoming from the Z decay we have plotted the mass spectra obtained with 3 different MC samples.

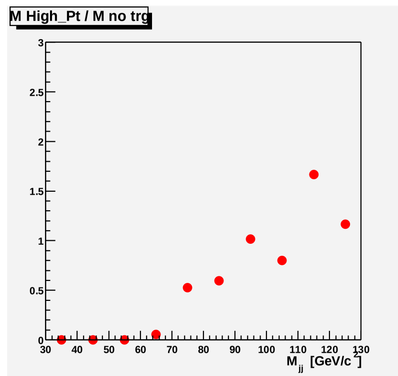
- Z events that fired the Z_BB ;
- Z events that fired the High_Pt;
- Z events without trigger cuts.

Applied offline cuts on events

- **2** $\Delta R = 0.7$ **jets** with $\mathbf{E_T^{raw} > 10}$ **GeV**;
- **2 SecVtX tags**;
- $\boldsymbol{\Delta\phi_{jj} > 3}$.





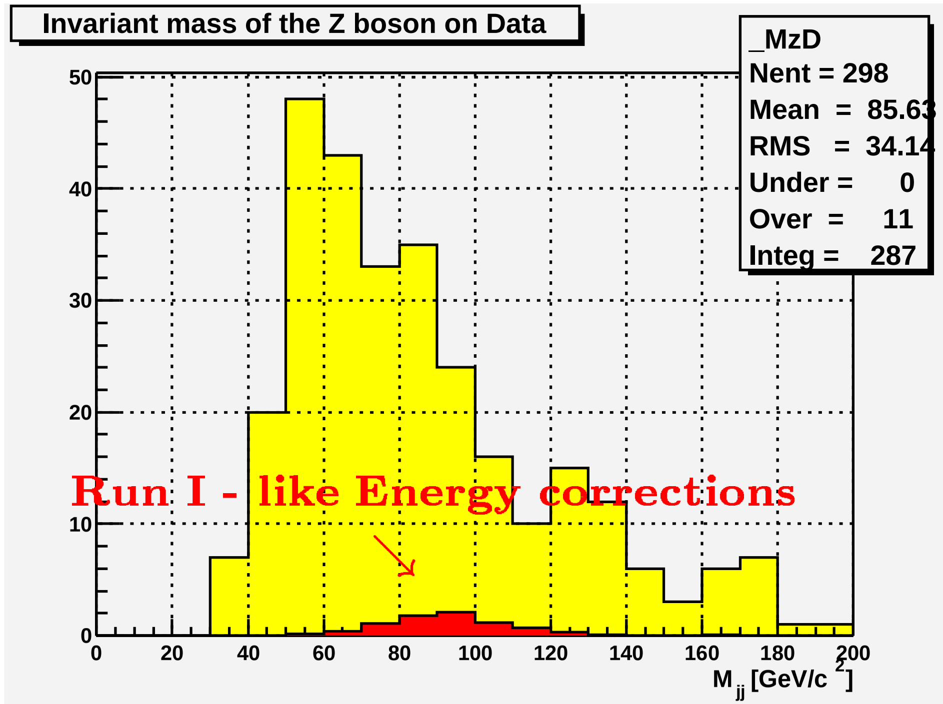


Data Sample: Z_BB

We have analyzed data collected between the runs 140886-142168. Using **lumsum.pl** code the estimated integrated luminosity of this sample is $\mathbf{L_{int} = 2.46\ pb^{-1}}$.
The number of data in ntuple is 29,090.
Using the estimated cross section for Z production in Run II enviroment, we find:
$\sigma_Z \times BR(Z \to b\bar{b}) = 1.18\ nb$

▶ The expected Z in the sample is

$\mathbf{L_{int} \cdot \sigma_Z \times BR(Z \to b\bar{b}) = 2,892}$.
$\mathbf{N_{exp} \cdot \epsilon_{trg} \sim 24\ evt}$



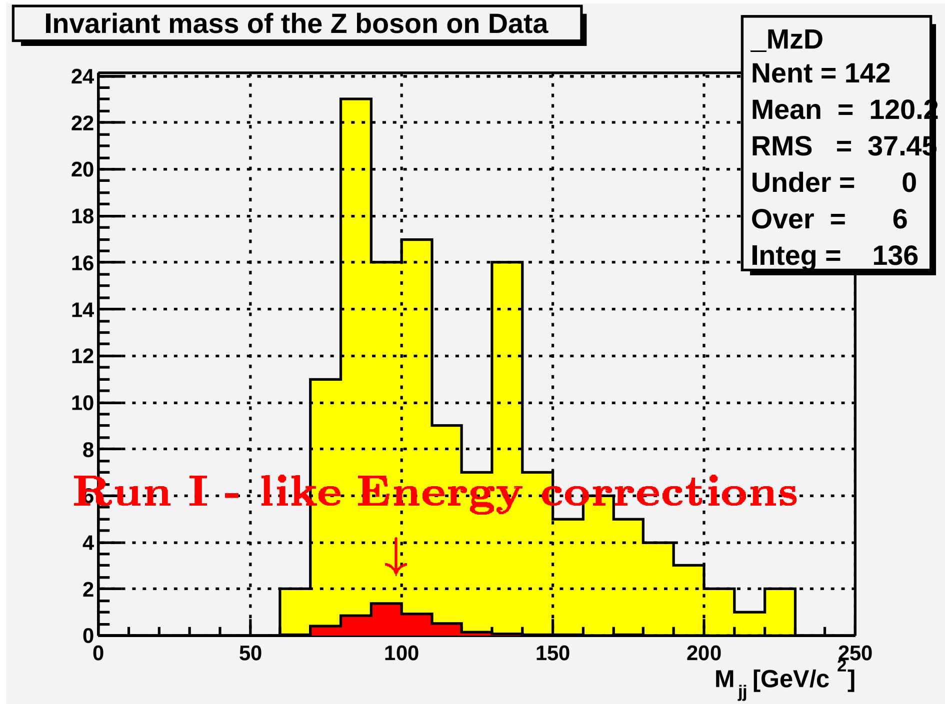
After analysis cuts, described previously, **we expect in the mass plot**
$\mathbf{\leq 8\ Zb\bar{b}}$ **events.**

Data Sample: High_Pt

We have analyzed data collected between the runs 141435-141544. Using **lumsum.pl** code the estimated integrated luminosity of this sample is **364 nb^{-1}**.
The number of data in ntuple is 39,036.
As before using the expected cross section for the Run II enviroment,

▶ the expected Z in the sample is

$$\mathbf{L_{int} \cdot \sigma_Z \times BR(Z \to b\bar{b}) = 428.}$$
$$\mathbf{N_{exp} \cdot \epsilon_{trg} \sim 26\ evt}$$



After analysis cuts, described previously, **we expect in the mass plot**

$\leq$ 4 $Zb\bar{b}$ events.

What can we do with the present data ?

- **SecVtX** is still far from being the tool we will end up using;
- **Jet energy corrections** are only an example extrapolated from Run I corrections and are not optimized for b-jets. ($\sigma_M \sim 16\ GeV$, in Run I $\sigma_M^{RunI} \sim 12\ GeV$);

Despite these caveats, it would be interesting to know how well we may constrain the **b-energy scale factor** and its **uncertainty** with 2 fb^{-1}, now that we have data to extrapolate from. In particular:

- Are the current trigger settings good enough for a useful b-energy scale factor ?
- Is the Z_BB trigger necessary for that task, given the small ϵ as compared to $High\_Pt$ path ?
- How dependent will any result be on the performance of SecVtX ?

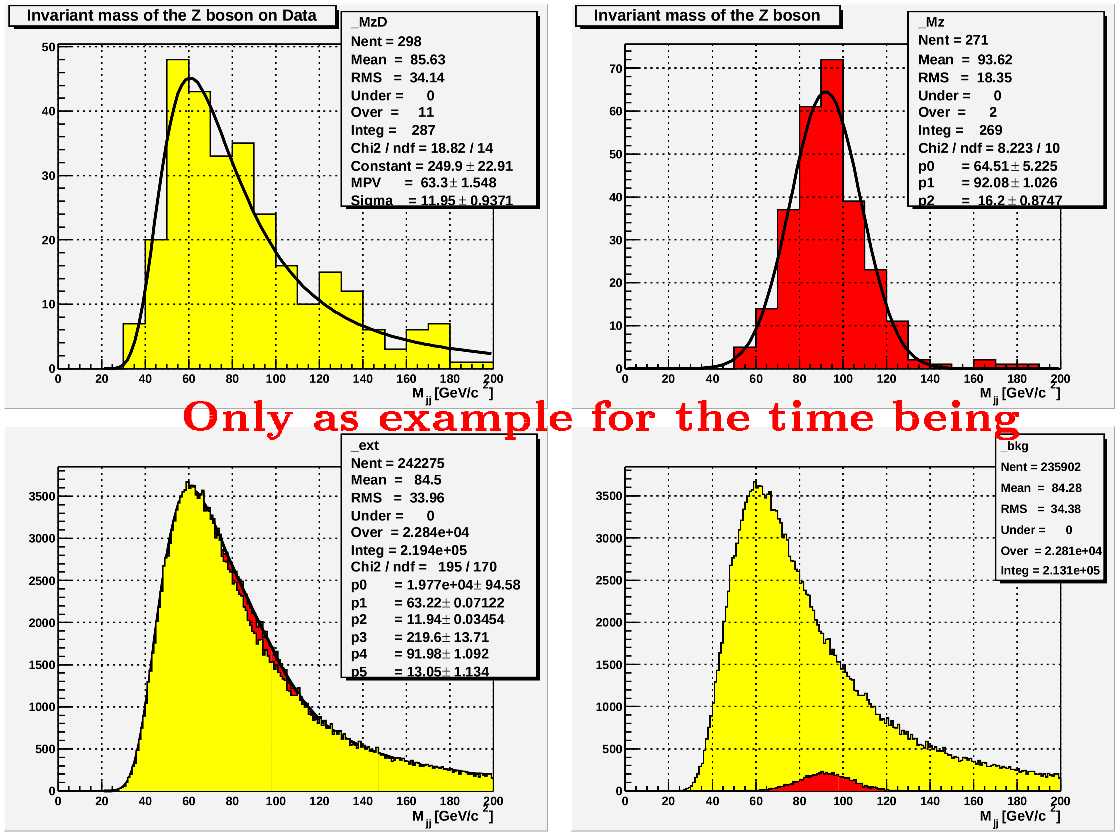
To answer these questions we put together a simple **program** that uses observed mass spectra **to extrapolate to 2 fb^{-1}**.

Extrapolation to 2 fb^{-1} : Z_BB

Fitting the shapes given by the invariant mass plot for signal and data, we extrapolate the invariant mass plot to 2 fb^{-1} using the pseudo experiment method.

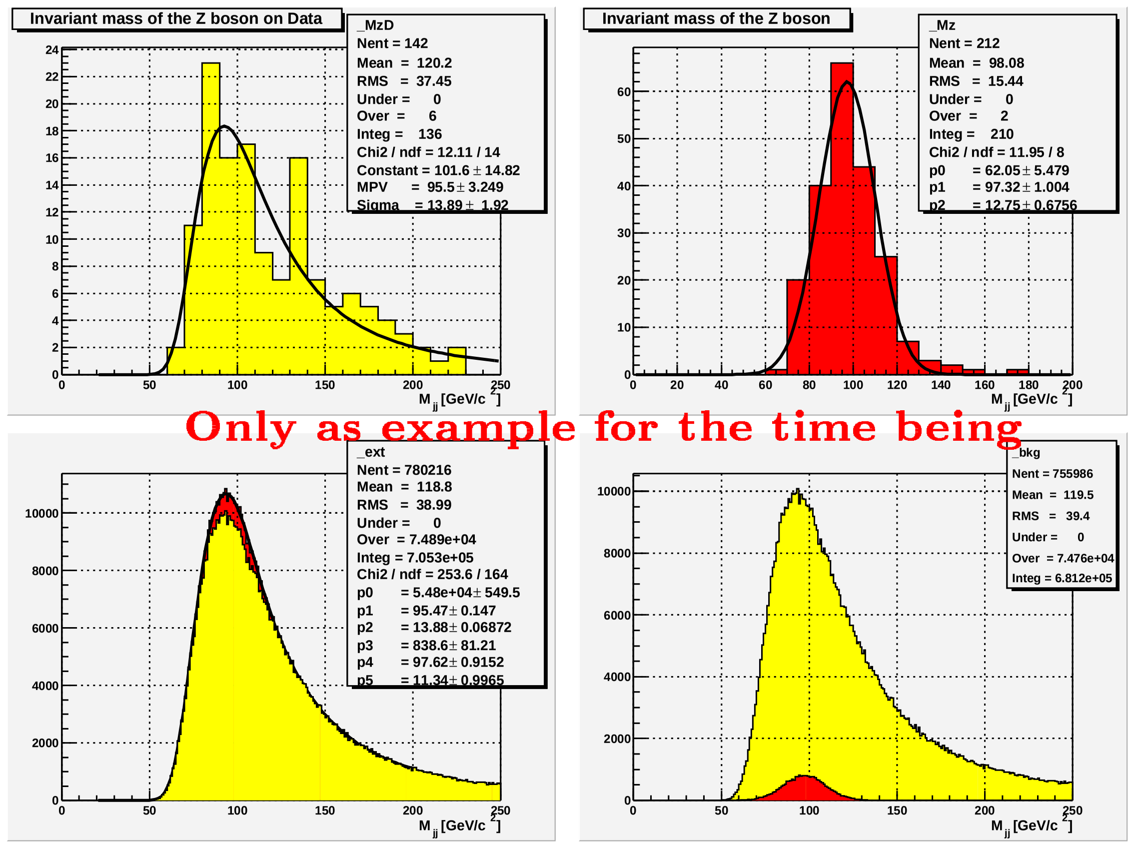
The results for the Z_BB sample is shown in the plot on the right, where the data are fitted using a landau function and signal using a gaussian.

Extrapolated data are fit to the sum the two functions with all parameters left free to vary but $\sigma_Z = 12\ GeV$ (as we expect form Run I after optimized b-jet corrections).



Extrapolation to 2 fb^{-1}: High_Pt

As for the Z_BB sample, a pseudo experiment extrapolation is performed for the High_Pt data sample. The results are in the plots on the right.



Only as example for the time being

Plans for the future: Understanding the sample composition

- The identification of $Z \to b\bar{b}$ is the first step for understanding the b-energy scale factor and its uncertainty.
- The composition for the collected sample of data is critical to reach this issue. This can be done in several ways:
  - Studying the L_{xy} distributions
  - Looking to the leptons associated to the b decays ($I.P.$ and P_T^{rel})
  - Constrain b/c fractions using J/ψ, D^*, ...
- Anyways, for the time being it is critical to wait for the optimization of SecVtX tagging algorithm.
- But in the meantime we have the possibility to understand if the trigger settings are good enough to reach a usefull precision on the b-energy scale. This will be the goal for our next future work.